Stimulating Simulations:
Java Applets Model Impact Cratering and Volcanic Eruptions.

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Planetary science is a supremely technology-based enterprise, yet much teaching of the subject relies on the traditional 19th century technique of lecturing. Lecturing is an efficient process for transmitting information from the professor's brain into classroom air, but there is little evidence that much permeates student brains. Nearly all pedagogical studies - and common sense - agree that learning is more intense and longer lasting if students perform meaningful experiments in which they interact with nature. This is difficult if the topic of study is impact cratering and volcanism. In order to support a course on the Geology of the Moon we have developed computer simulations which permit students to gain understanding of these two most important geologic process.

JavaBang!: To model explosive volcanic eruptions we have rewritten and modified an existing program called "Cinder Cone v.e24" (originally coded in Microsoft Quick BASIC by Dr. Jonathan Dehn [See: URL: http://www.aist.go.jp/GSJ/~jdehn/vmodel/ccdos.htm]) so that it runs as a Java Applet on any computer supporting Netscape or similar World Wide Web browser. Our version of the eruption simulation is based on a simple particle system, with 150 separate particles. The particle trajectory is semi-random based upon the parameters entered by the user.

Students may vary many parameters that affect the eruption, and visually see the consequences. Erupted material (pyroclastics) change horizontal and vertical distances traveled in response to the student's input. The parameters that can be changed are: gravitational field strength, maximum and minimum particle velocities, wind speed, minimum eruption angle, volcano's vent size, the density of the particles being ejected and the diameter of the particles being ejected [See: Figure 1].

Although JavaBang! can model the effects of gravitational acceleration and horizontal winds, we do not yet include the effects of atmospheric density in suppressing the movement of pyroclastics. Thus, our simulations for Venus and the Jovian planets mostly demonstrate the effects of planet mass on distance traveled.

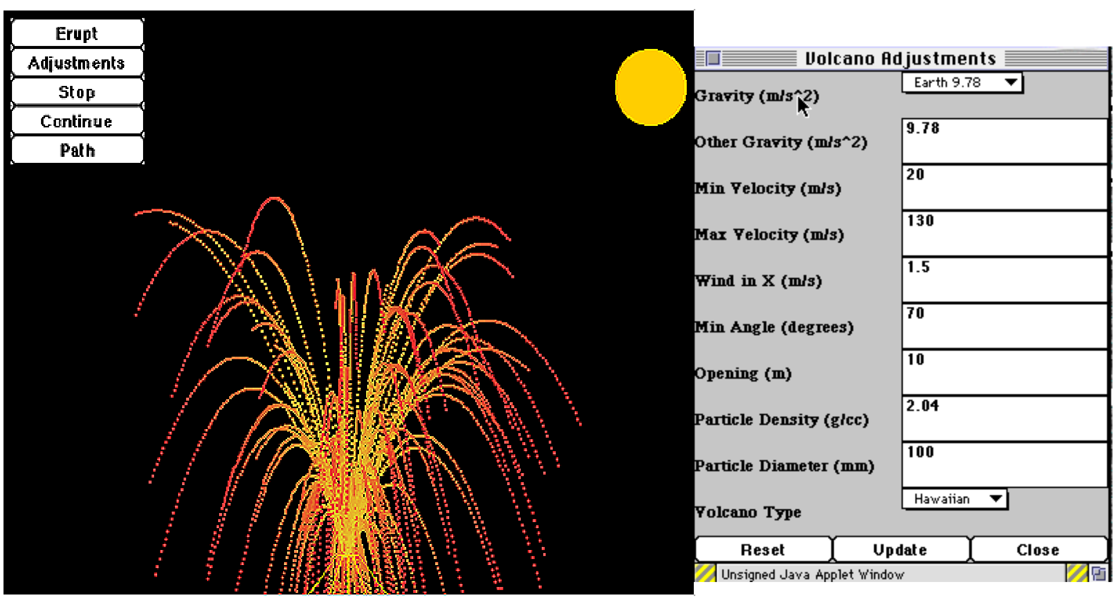

Figure 1: JavaBang!
URL: http://volcano.und.nodak.edu/vwdocs/kids/fun/volcano/volcano.html

JavaSplat!: Impact cratering is the most pervasive geologic process in the solar system. In our Geology of the Moon course students study the mechanics of crater formation, determine variations in crater morphology and morphometry with diameter, and do crater counts to estimate unit ages. All of these exercises seem to be enjoyable because students work with photos of the Moon and collect and compile their own data for analysis. But it is sometimes difficult for students to actually understand how crater densities change with time, and following resurfacing events such as lava flow eruptions. To allow students to experiment with the dynamic evolution of a landscape being cratered we have written JavaSplat! This Applet depicts on the computer screen an area of 300 km by 300 km on the modeled lunar surface. The program plots a series of circles/craters at random locations; the diameters are selected at random from the observed relation between lunar crater diameter (D) and the number of craters of that diameter: $N = cD^{-s}$ where c is a constant and s is the slope of the line. Each click of the mouse causes ten craters to form. As the circles are drawn on the computer screen, another window graphs both the number of craters formed of each diameter and how many are actually visible. The later function is necessary because the program removes craters that are covered by subsequent ones.

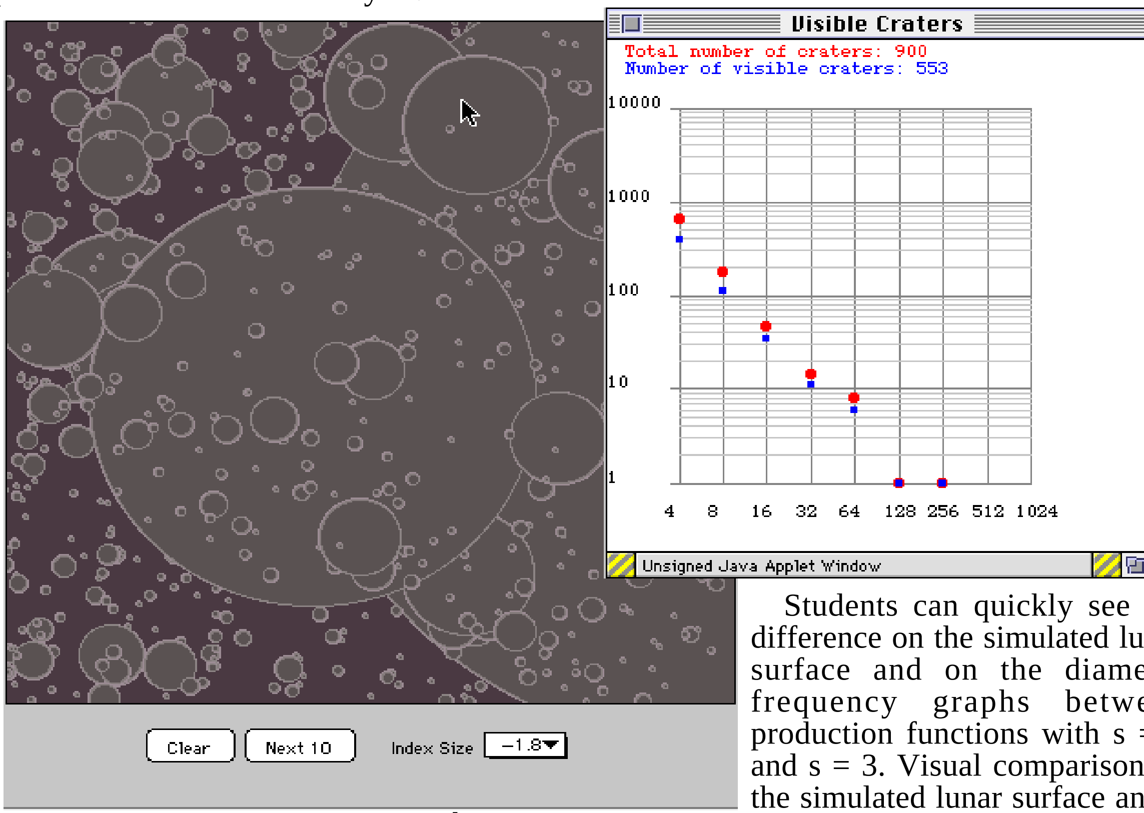

Figure 2: JavaSplat!
URL: http://volcano.und.nodak.edu/vwdocs/crater_sim/

Students can quickly see the difference on the simulated lunar surface and on the diameter frequency graphs between production functions with s = 1 and s = 3. Visual comparison of the simulated lunar surface and a photo of the lunar highlands convincingly shows that for the Moon s is about 2. The crater simulation exercise can also be compared to the results from actual crater counting on photos of the Moon. Future enhancements to JavaSplat! will include coloring of craters to mimic the USGS color-coding used to distinguish Copernican, Erastothenian, and older craters. Additionally, we plan to add an age scale that converts the modeled crater density to an absolute age. Other possible enhancements include modeling of craters smaller than our present lower limit of 4 km so that the affects of secondary craters can be investigated, and adding the effects of ejecta blankets.